

# Thallium scintigraphy in patients with angina at rest

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**SUMMARY** Sixty six patients with angina at rest were investigated by exercise electrocardiography, thallium scintigraphy, and coronary arteriography. A positive exercise electrocardiogram was highly predictive (93%) but poorly sensitive (52%) of coronary artery disease ( $\geq 50\%$  stenosis). Thallium scintigraphy was as predictive of the presence of coronary artery disease (91%) but was also highly sensitive (91%). The diagnostic contribution of the thallium scan was greatest in those patients with an inconclusive exercise electrocardiogram without Q waves.

The investigations recommended for patients with angina at rest vary from the conservative and expectant<sup>1</sup> to the highly invasive.<sup>2</sup> The invasive approach may be appropriate in selected patients referred to specialist cardiology centres after evaluation elsewhere, particularly when there is compelling evidence of ischaemic heart disease. Most clinicians managing rest pain, however, do not have easy access to coronary arteriography. Furthermore, a considerable minority of patients investigated because of chest pain seem to be free of ischaemic heart disease.<sup>3,4</sup> For these reasons and because of the small but real risk in coronary arteriography, a non-invasive test that could be applied widely outside specialist centres to patients with rest pain is attractive. Ideally, such a test would predict accurately the presence or absence of ischaemic heart disease. Thallium scintigraphy at the time of exercise testing is a well established non-invasive test of myocardial perfusion.<sup>5</sup> This study considers its value in the investigation of patients with rest pain.

## Patients and methods

In our cardiac unit between August 1982 and July 1983 we examined 124 consecutive patients aged <70 years who were admitted urgently because of angina at rest.<sup>6</sup> In this paper we review the 66 patients who received exercise electrocardiography, thallium scintigraphy, and coronary arteriography.

All patients had spontaneous chest pain at rest that

was typical of angina pectoris; they were free of serious intercurrent disease and gave their informed consent. All patients were treated initially with bed rest and conventional medical treatment (nitrates,  $\beta$  blockers, or calcium antagonists) and all became pain free soon after admission.

The treadmill exercise test was symptom limited and followed the Bruce or Naughton-Balke protocol; it was usually performed 3-10 days after admission to hospital.  $\beta$  Blockers were stopped in 20 of 57 patients. In all cases the exercise test was completed safely. The results of the test were regarded as positive if there was  $\geq 1$  mm planar or downsloping ST segment depression in three consecutive complexes or  $\geq 1$  mm depression of an upsloping ST segment 80 ms after the J point; as negative if 95% of the maximum predicted heart rate was attained without diagnostic ST segment change; and as inconclusive if the patient failed to attain 85% of the maximum predicted heart rate in the absence of a diagnostic change in the ST segment.

The thallium scintigraphy was performed in combination with the exercise test in all cases. About one minute before maximum stress 55.5 MBq thallium-201 was injected into an arm vein. After six minutes' rest, images were obtained consecutively in the anterior, left anterior oblique 45°, and left anterior oblique 70° projections. The images were collected for 10 minutes in each projection by an Ohio 420 mobile gammacamera with a high resolution collimator with a 25% window centred on the 80 keV peak. Late images were collected in the same way two and a half hours later. All images were stored on floppy discs and interpreted later by two experienced observers who were unaware of the diagnosis. The images were said to be positive (reperfusion, fixed defect, or both) or negative (no defect). If the two

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R J E Lee held a Royal Victoria Hospital Research Fellowship.

Accepted for publication 26 January 1988

observers did not agree a third observer also analysed the images.

Coronary arteriography with left ventriculography was carried out according to Judkins' technique not more than three months after the non-invasive tests. No new cardiac event occurred in the interim. No adverse events were associated with the procedure. The studies were interpreted blindly by one observer. A study was said to be positive for coronary artery disease when there was a  $\geq 50\%$  stenosis in a major vessel or a major branch of a major vessel.

## Results

We studied 48 men and 18 women (mean age 55 (range 35–69) years). Fifty eight patients had had previous episodes of angina and 24 had electrocardiographic Q waves.

### EXERCISE ELECTROCARDIOGRAPHY

Thirty (45%) patients had a positive exercise electrocardiogram, six (10%) a negative test, and 30 (45%) an inconclusive test.

### THALLIUM SCINTIGRAPHY

Thallium scintigraphy was positive in 54 (82%) and negative in 12 (18%) patients.

### CORONARY ARTERIOGRAPHY

Coronary artery disease ( $\geq 50\%$  stenosis) was present in 54 (82%) patients—15 single, 17 double, and 20 triple vessel disease. A further two patients had left main stem stenosis with triple vessel disease. Of 12 patients with normal coronary arteries, four had another lesion detected by ventriculography: one left ventricular hypertrophy, one hypertrophic obstructive cardiomyopathy, and two mitral valve prolapse.

### EXERCISE ELECTROCARDIOGRAPHY VERSUS CORONARY ARTERIOGRAPHY (Table 1)

The arteriogram was positive in 28 of the 30 patients with a positive exercise electrocardiogram, in two of the six patients with a negative exercise electrocardiogram, and in 24 of the 30 patients with an inconclusive exercise electrocardiogram. Thus the sensitivity of the exercise electrocardiogram for coronary artery disease was 52% (95% confidence interval 39%–65%) and its specificity was 33% (95% confidence interval 6%–50%). The predictive accuracy of a positive exercise electrocardiogram for the presence of coronary artery disease was 93% (95% confidence interval 84%–100%). The predictive accuracy of a negative exercise electrocardiogram for the absence of coronary artery disease was 67% (95% confidence interval 29%–100%).

### THALLIUM SCINTIGRAPHY VERSUS CORONARY ARTERIOGRAPHY (table 1)

The arteriogram was positive in 49 of the 54 patients with a positive thallium scan and in five of the 12 patients with a negative scan. Thus the sensitivity of the thallium scan for coronary artery disease was 91% (95% confidence interval 83%–100%) and the specificity was 58% (95% confidence interval 30%–86%). The predictive accuracy of a positive scan for the presence of coronary artery disease was 91% (95% confidence interval 83%–99%). The predictive accuracy of a negative scan for the absence of coronary artery disease was 58% (95% confidence interval 30%–86%).

### $\beta$ BLOCKADE AND THE EXERCISE ELECTROCARDIOGRAM

Thirty seven patients were receiving  $\beta$  blockers at the time of exercise testing. Of these, 17 (46%) had a positive exercise electrocardiogram, two (5%) a negative test, and 18 (49%) an inconclusive test. Of the 26 patients not on  $\beta$  blockers at the time of testing, 11 (38%) had a positive exercise electrocardiogram, three (11%) a negative test, and 12 (46%) an inconclusive test. We do not know whether three patients were or were not taking  $\beta$  blockers at the time of testing.

There was no significant difference in the proportion of patients with a definite exercise electrocardiogram result on or off  $\beta$  blockers.

### OUTCOME OF TESTING IN PATIENTS WITH AND WITHOUT Q WAVES

#### *Patients with abnormal Q waves*

Of the 24 patients with abnormal Q waves on their resting electrocardiogram, 11 (46%) had a positive exercise electrocardiogram, one (4%) a negative test, and 12 (50%) an inconclusive test. All but one patient (who had a positive exercise electrocardiogram) had a positive thallium scan and all 24 patients had a

Table 1 Results of exercise electrocardiography, thallium scintigraphy, and coronary arteriography in 66 patients with angina at rest

	Exercise electrocardiography					
	Positive (30)		Inconclusive (30)		Negative (6)	
	Pos	Neg	Pos	Neg	Pos	Neg
Thallium scintigraphy	25	5	25	5	4	2
Coronary arteriography						
Positive	24	4	23	1	2	0
Negative	1	1	2	4	2	2
Totals	25	5	25	5	4	2

positive arteriogram: four single vessel, eight double vessel, 11 triple vessel, and one left main stem stenosis (with triple vessel disease) (table 2).

The sensitivity of the exercise electrocardiogram for coronary artery disease was 46% (95% confidence interval 36%–56%) and the specificity was 0%. The predictive accuracy of a positive exercise electrocardiogram for the presence of coronary disease was 100%, and the predictive accuracy of a negative test for the absence of disease was 0%.

The sensitivity of the thallium scan for coronary artery disease was 96% (95% confidence interval 88%–100%) and its specificity was 0%. The predictive value of a positive thallium scan for the presence of coronary disease was 100%, and that of a negative scan for the absence of disease was 0%.

#### Patients without abnormal Q waves

Of the 42 patients without abnormal Q waves on their resting electrocardiogram, 19 (45%) had a positive exercise electrocardiogram, five (12%) had a negative test, and 18 (43%) had an inconclusive test. There were 31 (74%) patients with a positive thallium scan and 11 (26%) with a negative scan. Thirty patients had coronary artery disease: 11 single vessel, nine double vessel, nine triple vessel, and one left main stem stenosis (with triple vessel disease) (table 3).

The sensitivity of the exercise electrocardiogram for detecting coronary artery disease was 57% (95% confidence interval 48%–66%) and its specificity was 33% (95% confidence intervals 5%–60%). The predictive value of a positive exercise electrocardiogram for coronary disease was 89% (95% confidence interval 82%–96%). The predictive value of a negative exercise electrocardiogram for the absence of coronary disease was 80% (95% confidence interval 63%–97%).

The sensitivity of the thallium scan for coronary artery disease was 87% (95% confidence interval

81%–93%) and its specificity was 58% (95% confidence interval 44%–72%). The predictive accuracy of a positive scan for the presence of coronary disease was 84% (95% confidence interval 77%–91%). The predictive accuracy of a negative scan for the absence of coronary disease was 64% (95% confidence interval 49%–79%).

In the subgroup of patients without Q waves and with an inconclusive exercise electrocardiogram the thallium scan had a sensitivity for coronary disease of 92% (95% confidence interval 84%–100%). The specificity was 66% (95% confidence interval 47%–85%). The predictive value of a positive scan for coronary disease was 85% (95% confidence interval 75%–95%). The predictive value of a negative scan for the absence of disease was 80% (95% confidence interval 62%–98%).

#### Discussion

Up to 30% of patients with typical cardiac chest pain do not have ischaemic heart disease.<sup>4</sup> For this reason investigation of such patients to confirm or exclude a cardiac aetiology is important. It is perhaps self evident that Q waves on the electrocardiogram are diagnostic of ischaemic heart disease and such was the case in this study. Even when this clue is present, an exercise test is often arranged to assess exercise capacity, the degree and direction of ST segment shift, or the presence of ventricular extrasystoles. Also although thallium scintigraphy may be performed at rest<sup>7</sup> or during rest pain,<sup>8</sup> the best results are obtained with exercise.<sup>5</sup>

Nixon *et al* have shown that submaximal exercise testing is useful and safe in the evaluation of unstable angina.<sup>9</sup> In our study maximum exercise testing was performed safely in all patients. Some patients were taking  $\beta$  blockers, but there was no significant difference in the proportion of conclusive exercise

Table 2 Results of exercise electrocardiography, thallium scintigraphy, and coronary arteriography in 24 patients with angina at rest and Q waves

	Exercise electrocardiography					
	Positive (11)		Inconclusive (12)		Negative (1)	
	Pos	Neg	Pos	Neg	Pos	Neg
Thallium scintigraphy	10	1	12	0	1	0
Coronary arteriography						
Positive	10	1	12	0	1	0
Negative	0	0	0	0	0	0
Totals	10	1	12	0	1	0

Table 3 Results of exercise electrocardiography, thallium scintigraphy, and coronary arteriography in 42 patients with angina at rest and no Q waves

	Exercise electrocardiography					
	Positive (19)		Inconclusive (18)		Negative (5)	
	Pos	Neg	Pos	Neg	Pos	Neg
Thallium scintigraphy	15	4	13	5	3	2
Coronary arteriography						
Positive	14	3	11	1	1	0
Negative	1	1	2	4	2	2
Totals	15	4	13	5	3	2

electrocardiograms obtained in those patients who were taking  $\beta$  blockers and those who were not.

We found that a positive exercise test was highly predictive of ischaemic heart disease (93%) and that to a lesser degree (67%) a negative test predicted the absence of ischaemia. In these patients the thallium scintigram contributed little diagnostic information. A sizeable minority of patients with an inconclusive exercise test (30, 45%) remained. In these patients the thallium scan predicted the presence or absence of ischaemic heart disease in 27 (90%) of the 30 patients. In the 18 patients with an inconclusive exercise electrocardiogram without Q waves the thallium scan predicted the presence or absence of ischaemic heart disease in 15 (83%).

We conclude that maximal exercise testing may be performed safely in patients with rest pain soon after stabilisation on medical treatment. Thallium scintigraphy is a valuable diagnostic adjunct to the exercise electrocardiogram especially in those patients with inconclusive exercise tests and without electrocardiographic Q waves.

#### References

- 1 Mulcahy R, Daly L, Graham I, *et al.* Unstable angina: natural history and determinants of prognosis. *Am J Cardiol* 1981;48:525-8.
- 2 Olinger GN, Bonchek LI, Keelan MH, *et al.* Unstable angina: the case for operation. *Am J Cardiol* 1978;42:634-40.
- 3 Bennett JR. Chest pain: heart or gullet? *Br Med J* 1983;286:1231-2.
- 4 Wilcox RG, Roland JM, Hampton JR. Prognosis of patients with "chest pain ? cause". *Br Med J* 1981;282:431-3.
- 5 Gibson RS, Watson DD. Clinical application of myocardial perfusion scintigraphy with thallium 201. In: *Progress in cardiology* 12. Philadelphia: Lea and Febiger, 1983:67-112.
- 6 Lee RJE. Chest pain at rest—a prospective evaluation. The Queen's University of Belfast, 1985. MD Thesis.
- 7 Berger BC, Watson DD, Burwell LR, *et al.* Redistribution of thallium at rest in patients with stable and unstable angina and the effect of coronary artery bypass surgery. *Circulation* 1979;60:1114-25.
- 8 Parodi O, Uthurrault N, Sereri S, *et al.* Transient reduction of regional myocardial reperfusion during angina at rest with ST segment depression or normalisation of negative T waves. *Circulation* 1981; 63:1238-47.
- 9 Nixon JV, Hillert MC, Shapiro W, Smitherman TC. Submaximal exercise testing after unstable angina. *Am Heart J* 1980;99:772-8.

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